

REMARKS/ARGUMENTS

Claims 1-10 and 13-18 are pending. Claim 5 has been amended to delete language object to by the Examiner, and claim 6 is canceled. Claims 1 and 13 are amended to replace "0.5-4.5%" with --2.5-4.5%--. Support for this amendment can be found in the specification as indicated further below.

The drawings are objected to for failing to show every feature of the invention specified in claims 5 and 6.

Claims 1-10 and 13-18 are rejected under 35 USC 112, first paragraph, as failing to comply with the written description requirement.

Claims 1-8 are rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 6,351,018 to Sapp (hereinafter "Sapp") in view of the X. Chen et al. article titled "Fast Reverse Recovery Body Diode in High-Voltage VDMOSFET Using Cell-Distributed Schottky Contacts" (hereinafter "Cheng").

Claims 9 and 10 are rejected under 35 USC 103(a) as being unpatentable over Sapp and Cheng, and further in view of US Patent No. 6,437,386 to Hurst et al. (hereinafter "Hurst").

Claims 13-18 are rejected under 35 USC 103(a) as being unpatentable over Sapp in view of US Patent No. 5,998,833 to Baliga (hereinafter "Baliga"), and further in view of Cheng.

Objection to the Drawings

The drawings are objected to for failing to show every feature of the invention specified in claims 5 and 6.

With respect to claim 5, the Office action indicates that the drawings fail to show the claimed "second trench including a conductive material coupled to the conductive material in the first trench." Claim 5 has been amended to delete the language "coupled to the conductive material in the first trench." It is believed that this amendment eliminates the basis for the Examiner's objection to the drawings with respect to claim 5.

With respect to claim 6, the office action indicates that the drawings fail to show a particular claimed feature. This objection is moot given that claim 6 has been canceled.

35 USC 112 rejections

Claims 1-10 and 13-18 are rejected under 35 USC 112, first paragraph, as failing to comply with the written description requirement.

The Office action indicates that there does not appear to be a written description of the claimed "0.5-4.5%" range in the application as filed. It is believed that while this range is not explicitly cited in the specification, it is implicitly supported by the specification and the drawings of the present application, as set forth in the preceding Amendment. However, in an effort to expedite prosecution of this application, the claimed range "0.5-4.5%" has been changed to --2.5-4.5%--, for which explicit support can be found in at least paragraphs [0005], [0024], and [0030] of the present application. Withdrawal of rejection of claims 1-10 and 13-18 on the basis of the claimed range is respectfully requested.

With respect to claims 5, the Office action indicates that there does not appear to be a written description of the claimed "the second trench including a conductive material coupled to the conductive material in the first trench." The applicants respectfully disagree because one skilled in this art would recognize that in the FET section of the various devices shown and described in the present applications, many trenches would be present with the gate electrode in these trenches being electrically tied together. However, in an effort to expedite prosecution of this application, the language "coupled to the conductive material in the first trench" in claim 5 has been deleted.

With respect to the Examiner's rejection of claim 6, it is believed that this rejection is moot given that claim 6 has been canceled.

35 U.S.C. §103 Obviousness Rejections

Claims 1-8 are rejected under 35 U.S.C. §103 as being unpatentable over Sapp in view of Cheng. This is respectfully traversed.

With respect to claim 1, the Office action indicates that Sapp shows all the features of claim 1 except for the claimed range, and that the claimed range amounts to mere optimization, and is thus obvious. The Office action further indicates that the critical nature of the Schottky structure consuming the claimed range is not disclosed within the specification. Applicants respectfully submit that the critical nature of the Schottky structure consuming less than 5% of the active area of the device is in fact disclosed within the specification in several locations.

In paragraph [0030] of the specification, Applicants state:

The inventors have discovered, based on the simulation results as well as silicon data, that there is an optimum contribution of the Schottky structure area which maximizes the performance of the integrated device. More specifically, it has been discovered that a ratio of the total area of the Schottky structure to the total area of the MOSFET in the range of 2.5% to 5% results in optimum performance. In an exemplary embodiment wherein the MOSFET cell pitch is 2.5m and the pitch of a Schottky structure or a TMBS cell is 5m, a 2.5% ratio is obtained by forming one TMBS cell every 40 MOSFET cells.

The performance improvements resulting from the claimed range are documented in a number of places in the application. The amount of stored charge Q_{rr} for a Schottky diode has a significant effect in delaying the diode turn off. The delay time between the idealized turn-off time and the actual turn off time is called the reverse recovery time. As shown in Fig. 10 of the application reproduced below, the amount of stored charge Q_{rr} is at a minimum point "at about 2.5% Schottky structure contribution and rises rapidly with increasing Schottky structure area" (paragraph [0034]). Fig. 10 clearly shows that the stored charge Q_{rr} is at minimum levels for Schottky structure contributions of less than 5%.

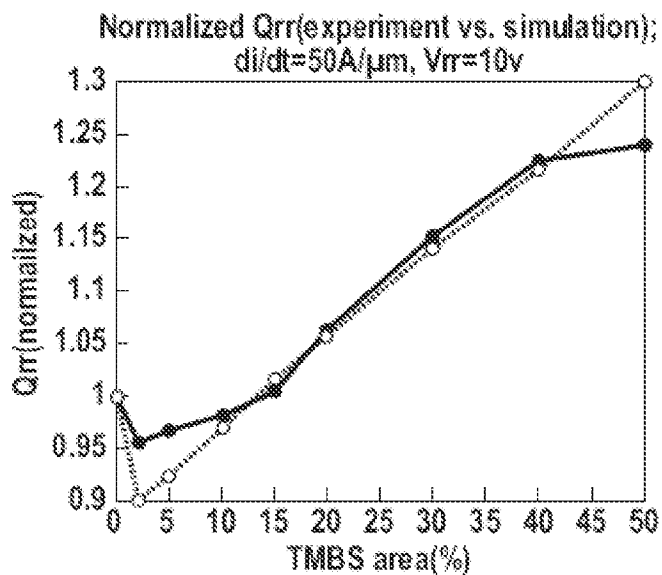


FIG. 10

Fig. 11 of the application reproduced below further reinforces the criticality of the Schottky structure consuming less than 5% of the active area. Efficiency values for a range of output currents are shown for different Schottky structure contributions. As can be seen, the low-side switches with less than 5% Schottky structure contribution possess the highest values for normalized efficiency.

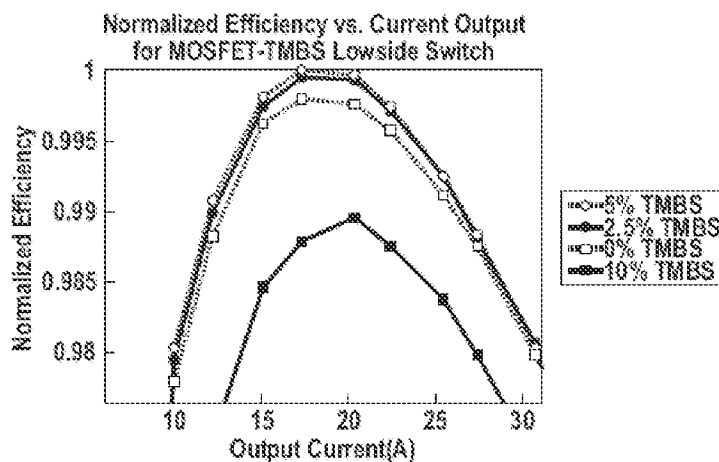


FIG. 11

Accordingly, Applicants respectfully submit that the critical nature of the claimed range of Schottky area is clearly set forth in the specification and the drawings.

The Office action further states that the claimed range is taught by Chen since Chen's disclosure discusses the entire range from 0-50%. This is respectfully traversed because Chen only considers the range of 15-50% (see page 1423, right column, lines 15-20), and neither contemplates nor suggests percentage Schottky area of less than 15%. The fact that Chen compares devices having 15-50% Schottky area with devices with 0% Schottky does not extend the range considered by Chen to below 15%.

In fact, Chen clearly advocates the higher end of the 15-50% range as more advantageous, and thus teaches away from using lower percentages of Schottky area. For example, Fig. 4 in Chen shows a superior reverse recovery characteristic for devices with the highest percentage (50%) Schottky (the curve marked as "Type f") as compared to devices with the lowest percentage (15%) of Schottky (the curve marked as "Type c"). A careful read of the Chen article as a whole makes clear that Chen considers the higher end of the 15-50% range to be more superior, and thus Chen teaches away from lower ranges.

Therefore, applicants believe claim 1 and its dependent claims distinguish over the cited references taken singly or in combination at least for the above reasons.

Claims 13-18 are rejected under 35 USC 103(a) as being unpatentable over Sapp in view of Baliga, and further in view of Cheng. This rejection is respectfully traversed.

With respect to claim 13, the Office action sets forth similar reasons for finding the claimed range obvious. It is respectfully submitted that claim 13 as amended includes the same numerical range recited in claim 1 and is thus believed to distinguish over the cited references taken singly or in combination for at least the same reasons as claim 1.

Further the Office action relies on the combination of Baliga, Sapp and Chen to arrive at the claimed structure. Applicants respectfully submit that combining the three references in the manner suggested by the Examiner is improper because the stated motivations for such combination are improper.

Applicants submit that the claimed combination of a trench structure with a shield electrode below the gate electrode together with a Schottky structure yields a superior device not contemplated by any of the cited references and any combination thereof. The present application in paragraph [0029] sets forth the superior characteristics of a structure (shown in Fig. 4A) which is similar to that claimed in claim 13:

The charge balancing effect of biased electrodes 411 allows for increasing the doping concentration of the drift region without compromising the reverse blocking voltage. Higher doping concentration in the drift region in turn reduces the forward voltage drop for this structure.

Given the importance of obtaining a low forward voltage drop for the Schottky structure, the presence of the shield electrode under the gate electrode enables the doping concentration of the drift region to be increased without compromising the reverse blocking voltage. The higher doping concentration of the drift region (which comes in contact with the barrier metal to form the Schottky structure) in turn reduces the forward voltage of the Schottky structure. Thus, the combination of a trench structure with a shield electrode below the gate electrode and a Schottky structure yields a superior structure that is neither taught nor suggested by any of the cited references.

Therefore, applicants believe claim 13 and its dependent claims distinguish over the cited references taken singly or in combination at least for the above reasons.

CONCLUSION

In view of the foregoing, Applicants believe all claims now pending in this Application are in condition for allowance. The issuance of a formal Notice of Allowance at an early date is respectfully requested.

Appl. No. 10/801,499
Amdt. dated May 3, 2007
Reply to Office Action of November 3, 2006

PATENT

If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 650-326-2400.

Respectfully submitted,

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